Predictive Modelling of Battery Degradation using Data-Driven Machine Learning Methods

Master Thesis/ Working Student

Description

Component degradation is an important concern in multiple industries. It affects not only the reliability but also the safety and efficiency of mechanical and electronic systems. Factors such as mechanical wear, thermal stress, corrosion, and environmental conditions contribute to the progressive degradation of components, resulting in higher maintenance costs and unexpected failures. Predicting and mitigating degradation through effective monitoring and modelling is crucial for all industries as downtime and failures can lead to considerable financial and operational costs.

One of the important applications of degradation modelling is in battery systems. Chemical and mechanical aging cause batteries' performance to diminish with time and usage. This results in reduced capacity, safety risks, and lower efficiency. The State of Health (SoH) and Remaining Useful Life (RUL) of batteries are determined using conventional physics-based techniques, frequently computationally demanding and dependent on substantial empirical testing. As a result, data-driven machine learning methods have emerged as powerful tools for capturing degradation patterns and improving predictive accuracy.

Machine learning algorithms are commonly used in predictive modelling to assess sensor data, detect abnormalities, and forecast degradation trends. Random Forests, Support Vector Machines (SVM), and Deep Neural Networks (DNN) have been used successfully to identify early-stage degradation trends in complicated datasets. Reinforcement learning methods can be used to optimize maintenance strategies by dynamically adjusting Depth of Discharge (DoD) based on real-time degradation trends. Since sensor data only provides snapshots of the system's current state, the goal of this thesis is to use existing battery degradation datasets to assess system health and predict reliability in future time domains. Second major task would be working and developing a data pre-processing standardization module so that different types of sensor data can be used for the predictive models. This approach will not only enhance our understanding of system behaviour under current operating conditions but also enable more accurate predictions of Remaining Useful Life (RUL) under both stable and varying conditions, ultimately improving maintenance strategies and extending component lifespan.

Tasks

1. Literature Review on existing Machine Learning methods for battery degradation modeling
2. Develop a universal Data Pre-processing Module based on parameters used in different Battery Management Systems (BMS) with different sensor datasets.
3. Implement ML models to predict component lifespan and failure modes under normal and changing operating conditions
4. Document findings and contribute to at least one research paper

DLR Institute of Maritime Technologies and Propulsion Systems

About the DLR Institute of Maritime Technologies and Propulsion Systems

At the Institute of Maritime Technologies and Propulsion Systems, we provide technological developments to give the maritime industry security for its investment decisions in new technologies and thus accelerate the transformation of waterborne transport. Shipping is essential for the economic well-being of the world and handles 80 per cent of international freight traffic. Therefore, the maritime industry needs reliable ship concepts and technologies to fulfil different and typically unique transport tasks with unique ship concepts.

The institute's vision does not stop at the quay wall, but considers the ship as a system in a global transport concept with its own interfaces to air and land transport. Our international team of over 100 employees is working on energy-saving drives, efficient energy generation on board, fuel cells, optimised ship designs, safe energy storage and solutions for emission-free fuels and their infrastructure in ports and on board. Among other things, we work with analytical and AI-based modelling, simulations and numerical calculations and, in future, in a comprehensive laboratory environment. In future, we will have access to the institute's own research vessel for practical testing, validation and data collection.

We see ourselves as integrators for emission-reduced systems in an ideal maritime research and industrial landscape between the Elbe, Baltic and North Seas.

To support this vision, the department of Ship Reliability conducts research to analyse and evaluate structural challenges. Experimental and numerical methods are being developed that allow reliability to be assessed even under extreme conditions. The areas of application range from component testing and risk assessment to real-time monitoring with fault detection systems, the optimisation of structural design and the development of guidelines for structural and system design. In all areas, the focus is on being able to digitally map real systems with a high degree of accuracy, whether on land, in the laboratory or in use under maritime conditions at sea, thus ensuring safe operation at all times.

The institute is located in Geesthacht and Kiel.

Qualifications

- Currently pursuing a Master's degree in Computer Science, Data Science, Mechanical/Electrical Engineering, or a related field
- Strong background in machine learning, deep learning, and data analysis
- Experience with Python and ML frameworks (e.g., TensorFlow, PyTorch, Scikit-Learn)
- Knowledge of signal processing and time-series analysis is a plus
- Analytical mindset, independent, and problem-solving skills

Contact

Should you have any questions regarding this position, please contact

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